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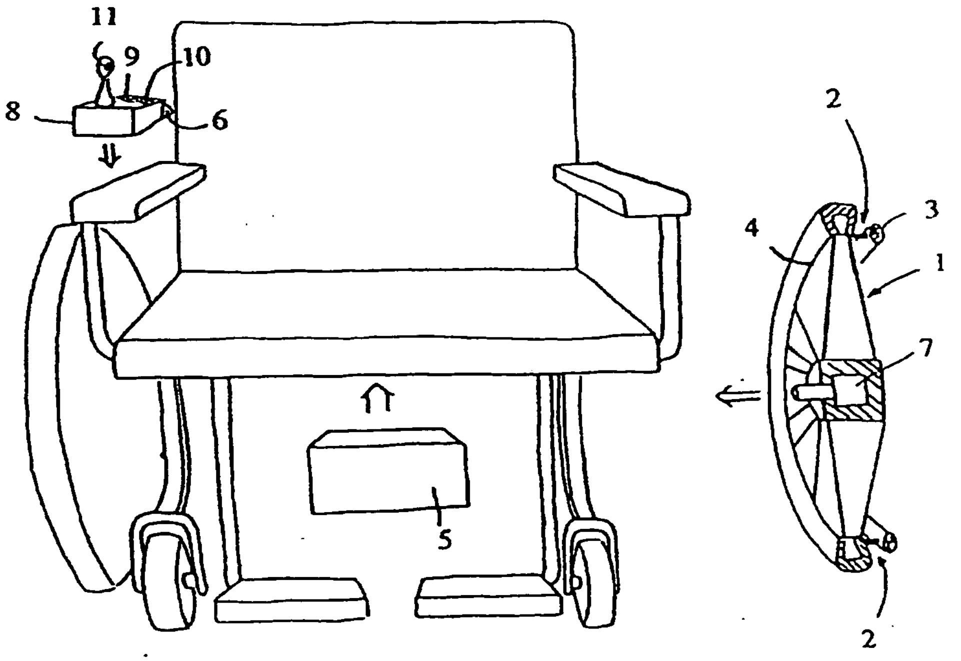
(54) Title: A WHEEL DEVICE FOR A WHEEL CHAIR

(57) Abstract



The invention is intended to provide a measuring chair function which will enable the propulsion force applied to a drive ring by the chair user to be measured, and also to provide an electrically operated powerservo on conventional, manually driven wheelchairs. Power or force sensors (2.1) are placed adjacent a respective attachment between drive ring (3) and wheel (4) and function to measure the propulsion force applied on the drive ring by the user. The drive ring is also held by other types of attachment means (2.2) which lack the provision of power or force sensors and which solely provide a force effect in an axial direction and which have the smallest possible effect in the peripheral direction of the drive ring. Each wheel can be substituted for the conventional wheel of a wheelchair and includes quick coupling means to this end. Furthermore, each wheel may be provided with a drive assembly (41) including a motor (64) which can be controlled in response to the measurement signals delivered by the power sensors. A computer unit (56) receives the power signal (55) from each wheel, the wheel speed (57) and also the settings chosen by the user and entered on an instrument panel (8), and calculates useful user information and is effective in controlling the motor in accordance with a variable program, in such instances when the arrangement includes a motor.

A WHEEL DEVICE FOR A WHEEL-CHAIR.

Description

The present invention is concerned with the provision of an electric powerservo on conventional, manually activated wheelchairs, and also with the provision of a wheelchair measuring function on conventional types of wheelchairs in which a drive ring is coupled to each of the chair drive wheels for the purpose of measuring the forward propulsion force applied to the drive ring by the user.

Wheelchairs are either powered manually or electrically. Electrical wheelchairs are needed when the handicapped person is unable to propel a wheelchair manually by himself/herself. There are a large number of people who are bound to a wheelchair and who have control over their arm movements but lack the physical strength to propel a wheelchair manually. All of those belonging to this group are compelled to use electric wheelchairs that are equipped with joystick controls, since no other type of electric wheelchair that can better satisfy the need of such people is available commercially.

The problem (the fault) with such joystick-controlled chairs is that they do not utilize the power resources of the user, resulting, among other things, in passivation or inactivation of the user's arm muscles, and also causing the user to feel more handicapped than he/she actually is.

There are also a number of situations in which it is desirable to obtain a correct and objective assessment of the strength and fitness of a handicapped person and also of the technique used by such a person when propelling a manually-driven wheelchair. This objective assessment is wheel. This wheel drive is mounted on the actual wheelchair itself, and thus not on each separate wheel. The additional propulsion force, or booster force, is calculated with the aid of conventional circuits which cannot be adjusted automatically on the basis of the working performance of the handicapped persons themselves. The equipment described is bulky and results in relatively wide wheels. The solution does provide for some manual adjustment possibilities, however.

One object of the present invention is to provide a robust, simple and inexpensive arrangement for measuring the force that is applied to the drive wheels of a wheelchair by the user, wherein it is possible to use the wheelchair as a measuring instrument.

Another object of the invention is to provide an arrangement by means of which the force applied by the user under different driving conditions during the course of wheelchair movement can be noted and recorded.

Another object of the invention is to provide a wheel arrangement which can be readily substituted for the normal wheel assembly of a conventional wheelchair.

Still another object of the invention is to provide a wheel arrangement for an electric wheelchair with which the user's own resources are utilized, and with which the wheelchair solely adds the additional force required to propel the wheelchair forwards in all conceivable situations, i.e. an individually controllable powerservo. The user controls the wheelchair in the same way as when controlling a conventional, manually activated wheelchair and will feel stronger as a result of the additional force delivered by the wheelchair and therewith be able to propel the wheelchair to places which were earlier out of range.

person using the wheelchair, the speed at which the wheelchair is propelled, the total power used in propelling the wheelchair, the distance travelled and the time taken to cover said distance, and so on, therewith providing the user of the wheelchair with feedback regarding his/her driving of the wheelchair as the chair is driven. The computer includes memory devices which enable measurement data to be collected and processed to some extent as the wheelchair is propelled by the user.

* The computer fitted to the wheelchair has a capacity sufficient to present the driving result. The calculating capacity of the chair-mounted computer can be increased, however, by transferring stored series of signals from the chair-mounted computer to a stationary, external computer of greater capacity with regard to software and display screen, for instance to a personal computer. The information can be stored so as to enable it to be recovered on later occasions and compared with the results of fresh test runs.

This type of measuring wheelchair, or instrument, has several areas of use. Since the measuring wheelchair provides an objective and correct assessment of the strength of the test person and his/her technique in propelling a wheelchair, it can be used advantageously in conjunction with the rehabilitation of wheelchair-bound people. In this regard, it can be used by therapists and physiotherapists as an instrument for planning a proper training program for each individual, and also to provide a concrete basis for the type of wheelchair that a user may be given in order for the user to utilize his/her own power and individual driving technique to the best extent. The inventive wheelchair can also be used as a stimulant for injured persons, since they are able to see in plain figures the extent of their improvement during rehabili-

Fig. 7A	is a schematic overview of the signal flow through the system;
Fig. 7B	illustrates a microprocessor unit for the system shown in Fig. 7A; and
Figs. 8A-8D	are diagrams which illustrate different control possibilities relating to wheel-mounted drive assemblies.

The wheelchair shown in Fig. 1 can be fitted with a new drive wheel 1 with the aid of an attachment means 2 placed between a drive ring 3 and a wheel rim 4 as a module, such as to render the invention independent of the type of wheelchair concerned. As shown schematically to the right of the Figure, the wheels can be substituted for the conventional wheels of a wheelchair in accordance with the invention. Signals produced by power or force sensors on part of the attachments on and the sensed wheel speed are transmitted to a calculating unit, preferably in the form of a computer, such as a microcomputer housed in a box 5 together with batteries, etc., and fitted to the chair. The result of the calculations made by the unit 5 can be shown on a display unit 6, which may be fitted to the wheelchair so as to enable the result to be easily seen by the user. The wheels may also be fitted with a drive motor 7 which functions to deliver additional power to the wheels when necessary, in response to a control from the calculating unit. The display unit 6 may be housed in a setting control box 8 provided with knobs or keys 9 and 10, for instance, by means of which the user is able to set that power level for each wheel from which the additional power shall be delivered. The calculating unit may also be provided with software or the like which will allow the user to switch to a control lever 11, or joystick, when desiring to use this type of forward propulsion control means instead of the drive rings.

Figs. 2A-2C illustrate a first embodiment of an inventive sensors. According to the present invention, this possibility is utilized to reduce the number of power sensors required, preferably down to two. The invention is not limited, however, to only two power sensors.

As indicated in Figs. 2A and 2B, the attachments between the drive ring 3 and the rim 4 are of two different kinds, of which one kind 2.1 functions to hold the drive ring and the wheel rim so that force from the drive ring 3 will be transmitted in all directions and then also tangentially to the wheel rim 4, and where the second type of attachment 2.2 functions to hold the drive ring in relation to the rim so that force from the drive ring will be transmitted to the wheel rim essentially solely in the direction of the wheel axle, i.e. it will not take-up load in the plane perpendicular to the wheel axle 15. This means that all forces acting in the plane extending at right angles to the wheel axle 5 and transmitted from the drive ring attachments to the wheel are taken-up by the attachments 2.1 provided with power sensors.

To prevent the drive ring from wobbling and feeling limp or flimsy to the user, there will preferably be at least four attachments between the drive ring 3 and the wheel rim 4. It is essential in this regard that the drive ring is maintained parallel with the wheel rim.

Fig. 2B illustrates one embodiment of the attachment 2.2. The attachment is pivotal in all directions with regard to both drive ring 3 and wheel rim 4, through the medium of two pivotal or universal connections 13.

Fig. 3 illustrates another embodiment of the attachment which lacks a power sensor. Thus, there is shown an attachment 2.20 which has a modulus of elasticity which is negligible in comparison with the modulus of elasticity of the attachment(s) 2.1 having power sensors. This means that curved. It is also conceivable to attach some type of frame structure to the wheel at its different types of attachment or holder against which the drive ring is secured, or alternatively the different types of holder may be mounted directly onto the wheel hub, which must then be stable.

As illustrated in Fig. 2A, the measuring bridge is connected to a measurement signal amplifier and to a bridge supply circuit 22, which is also connected by a cable 23 to a unit 24 mounted on the wheel hub and provided with means for slip-ring transmission of voltage supply and of measurement signals from the power sensors 18, and which is provided with a speedometer. The circuit 22 will also preferably perform signal processing operations, with conversion of the detected or sensed analog signal ΔU to a pulse signal of different frequency, said frequency being dependent on the magnitude of the signal ΔU.

As shown in Fig. 2B, one part 26 of the unit 24 is provided with slip ring tracks in accordance with Fig. 2C and is placed so as to be co-rotational with the wheel, while another part 27 of said unit is placed so as to be held stationary on the wheelchair. This can be achieved by using the hollow bolt and its polygonal screw head, which is stationary on the majority of wheelchairs, such as to hold the wheel axle 15, with its screw head as an anvil surface or counterpressure surface, and by providing the part 27 with a central opening having a configuration adapted to the configuration of the screw head.

The wheel, drive ring 3, power sensor 2, signal transmission means thus form a replaceable module 1. The module 1 may also include a drive assembly or drive package 41 described below with reference to Fig. 5. This module construction which can be coupled to the wheel of the wheelchair both quickly and simply enables the inventive wheel to be readily fitted to and removed from different a wheelchair. However, in this case, it is necessary to provide the wheelchair with an anvil means or counterpressure means, in order to make the change possible. It must be possible to secure the axle in a rotationally free manner, and arrangements to this end are well known to the skilled person and will not therefore be shown and described in detail; see for instance German Patent Specification No. DE-41272577. The signals produced by the power sensors may be transmitted with the aid of a slip ring contact also in the case of this embodiment, although in the illustrated case the pulses obtained from the circuit 22 (see Fig. 2A) are shown to be coupled to an IR light-emitting diode 121 which transmits the pulses in the form of IR light which is received by an IR phototransistor 122 fitted to the wheelchair S. The pulse signals received by the IR phototransistor 122 are converted to signals which can be read into the microcomputer unit 56. In the case of this embodiment, the circuit 22 includes a battery for powering the power sensors.

Figs. 6A and 6B illustrate in detail another embodiment of the slip ring transmission system and the quick-coupling unit used in accordance with the invention. Naturally, this type of transmission can be used with both types of wheel, i.e. with or without the drive assembly. However, as mentioned above, it is necessary in the case of wheels that are equipped with a drive assembly to provide a separate arrangement which will ensure that the wheel axle is stationary in relation to the wheelchair. A chair-holding unit 42 (not described in detail) having a stationary bolt 43, for instance a hollow bolt, provided with a polygonal head 44 is provided for accommodating the wheel axle of the wheelchair drive wheel. Each wheel 45 is provided with a hollow axle 46 which is connected to the wheel through the medium of ball bearings. The axle 46 is held in place by balls 48 or the like which are moved outwardly of the inner to the wheelchair. Arrangements for achieving this are well known to the art and will not therefore be described here. For instance, the wheel axle can be clamped in the vicinity of the bolt 43.

As illustrated in Fig. 7A, the torque signal 55 obtained, i.e. the converted measurement signal ΔU, is transmitted from each of the drive wheels 1 to the wheelchair and is there delivered to a microcomputer unit 56 housed in the box 5 (Fig. 1). In addition to this signal, the microcomputer unit 56 also receives information 57 relating to the speed of each drive wheel 1 and information 58 relating to the settings made on the instrument panel 8. The microcomputer unit 56 performs the selected function on the basis of these signals as input data.

When choosing to use the wheelchair in its measuring capacity, the microcomputer unit 56 will store at least the measurement signals 55, 57 in its memory.

The memory can then be read and the memory contents transferred by the microcomputer unit 56 to a conventional personal computer 59 for further processing, through the medium of a multi-pole contact device 60.

When a control program for wheels that are provided with an additional drive assembly 41, including a motor, is selected, the microcomputer unit 56 will calculate the additional force that shall be added to the force exerted by the user and then control the drive assembly 41 with the signal 43 individually for each of the wheels. Control signals for the display unit 6 on the instrument panel are delivered through the cable or line 67.

In order for the aforesaid inventive arrangement to be realized, there is required a unit which is able to process the incoming signals quickly. A conventional computer unit a linearly increasing force addition, Fig. 8B shows a force addition, or force booster, which varies exponentially between the set level beneath which no force booster is produced, and a level of maximum force on the drive rings. This control strategy produces approximately the same force on the drive ring irrespective of the resistance offered by the surface along which the wheelchair moves. The time diagram shown in Fig. 8C illustrates the performance of a control strategy intended to provide linear amplification with integration of the force in those instances when the wheelchair does not begin to roll forwards. This control strategy can be applied when negotiating obstacles, such as raised thresholds, pits or depressions in the floor, etc. After a first time lapse between τ_1 and τ_2 with linear amplification of the measured drive torque and failure to detect wheel speed, the additionally applied drive torque is increased until a wheel speed is detected at time point τ_3. The additionally applied torque is then lowered to the torque value that prevailed during the first time period. When the detected torque on the drive ring has fallen to zero at time point τ_4, the applied drive is reduced to a lower value, which is maintained until the wheel speed has decreased to zero, i.e. the wheel is stationary. Fig. 8D illustrates a control strategy in which a mean value is formed with the intention of reducing the effect of vibrations in those instances when the wheelchair is used by spastics. The torque measured at a given instance and shown in the upper diagram is divided into a time window with time T. A mean value of the drive torques within respective windows is formed and results in the measured torques illustrated in the lower diagram, which is used to calculate the additional force required on a drive wheel, for instance in accordance with the principle shown in Fig. 8A.

The measuring chair program and the control program can be combined and operated in parallel, therewith enabling the data storage.

It will be observed that the problem of transmitting signals from a rotating wheel to the wheelchair can be solved in ways other than that described with reference to slip ring transmission, for instance by cordless transmission with the aid of IR light or radio signals. One example of signal transmission is to transmit the amplified measurement signal in the form of a pulse train having a frequency which is linearly dependent on ΔU.

The microcomputer 56, the instrument panel 8 and the drive assembly 41 are powered electrically by batteries placed in the box 5 on the wheelchair. The means for measuring torque and transmitting signals may be powered by the wheelchair batteries, as illustrated with the slip ring unit shown in Fig. 2C, or by a separate battery, or by means of some other electric current source mounted on the wheel, for instance in the unit 22.

As seen on the part of the user, the inventive powerservo effect for manual wheelchairs will be experienced as a "conventional" manual wheelchair, but with the difference that the user will feel stronger in the arms.

The powerservo function will satisfy the whole of the human spectrum found in the ranges of those who can almost manage a manual wheelchair and those which are able to control their arms but are unable to propel a manual wheelchair.

The measuring chair function afforded by the present invention provides a correct and an objective measuring instrument which can be used to map the strength, fitness and technique of a wheelchair user when driving the wheelchair.

These functions can be used either together or individually

CLAIMS

1. A wheel arrangement for wheelchairs comprising means for measuring the force applied to a drive ring (3) by a user of the wheelchair, wherein the drive ring is connected to a wheelchair drive wheel (4) through the medium of attachments (2.1, 2.2), **characterized** in that the attachments comprise at least two different types of attachment, of which the first type of attachment (2.1) includes power or force sensors (18) and provides a holding effect in all directions, and of which the second type of attachment (2.2) provides a holding effect essentially solely in the direction of the wheel axle.

2. A wheel arrangement according to Claim 1, **characterized** in that the first type of attachment (2.1) are two in number.

3. A wheel arrangement according to Claim 1 or Claim 2, **characterized** in that the drive ring (3), the drive wheel (4) including the attachments (2.1, 2.2) form part of a wheel assembly which can be substituted for a wheel of a conventional wheelchair; and in that said assembly includes electronic means (22) and signal transmission means (24; 51, 54) for transmitting signals to a computer unit (5; 56), which may be mounted on the wheelchair.

4. A wheel arrangement according to any one of the preceding Claims, **characterized** in that the drive wheel (4) is provided with a drive assembly or drive package (41) which includes a wheel drive motor (64) which can be controlled on the basis of the signals received from the power sensors.

5. A wheel arrangement according to Claim 3 or Claim 4, **characterized** in that the computer unit (36) is programmed for calculating continuously the force applied on each

supply to and signals from the power sensors (18), and which further includes a first part (51) which is firmly mounted adjacent the hub (45) and a second part having a cavity which is intended to be fitted over a unit (44) firmly seated on the wheelchair, said unit (44) having the form, for instance, of a centrally positioned unit having a polygonal outwardly turned periphery and positioned adjacent a wheel axle accommodating opening; and in that the wheel has an extended wheel axle (46) which includes a coupling means (48, 50) which can be fitted into said opening so as to hold the wheel in an axially direction, such that the second part will be located around the unit (44) having said polygonal periphery.

10. A wheel arrangement for a wheelchair, comprising a wheel having a drive ring attached to the wheel with the aid of a plurality of attachment means that include power or force sensors which function to measure the propulsion force acting between the drive ring and the wheel, characterized in that the arrangement includes a slip ring transmission means (51-54) placed adjacent the wheel hub and operative in transmitting power supply to and signals from the power sensors (18), and further including a first part (51) which is secured firmly to the hub (45) and a second part which has a cavity which is intended to be fitted onto a unit (44) which is firmly seated on the wheelchair, for instance a centrally placed unit having a polygonal outwardly facing periphery and positioned adjacent an opening for accommodating a wheel axle; and in that the wheel has an extended wheel axle (46) which includes a coupling means (48, 50) for attachment in said opening so as to hold the wheel in an axially direction such that the said second part is located around the unit (44) having said polygonal periphery.

11. A wheel arrangement according to Claim 10, characterized in that the second part of the slip ring

wheel having a drive ring attached to the wheel and including a plurality of attachments provided with power or force sensors which are adapted to measure the forward propulsion force between the drive ring and the wheel, **characterized** in that the arrangement includes a drive assembly (41) which, in turn, includes a motor (64) which can be controlled on the basis of the signals delivered by the power or force sensors (18) such as to effect forward propulsion of the wheel when necessary.

16. A wheel arrangement according to Claim 15, **characterized** by a quick coupling (44, 53, 48, 50) which is adapted to means mounted on the wheelchair so as to enable the wheel arrangement to replace a conventional wheel.

17. A wheel arrangement according to Claim 15 or Claim 16, **characterized** in that the arrangement includes slip ring transmission means (51-54) mounted adjacent the wheel hub and functions to transmit power to and signals from the power sensors (18) and the drive assembly (41), said transmission means including a first part (51) which is mounted firmly adjacent the hub (45) and a second part having a cavity which is intended to fit over a unit (44) firmly mounted on the wheelchair, for instance a centrally placed unit having a polygonal, outwardly turned periphery and positioned adjacent wheel axle accommodating opening.

18. A wheel arrangement according to any one of Claims 15-17, **characterized** in that the wheel is provided with electronics (22) and a signal transmission unit (24; 51, 54) for transmitting signals from the power or force sensors to a computer unit (5; 56) which can be mounted on the wheelchair and which functions to calculate the control of the drive assembly on the basis of the signals delivered by the power sensors.

19. A wheel arrangement according to any one of Claims 15-

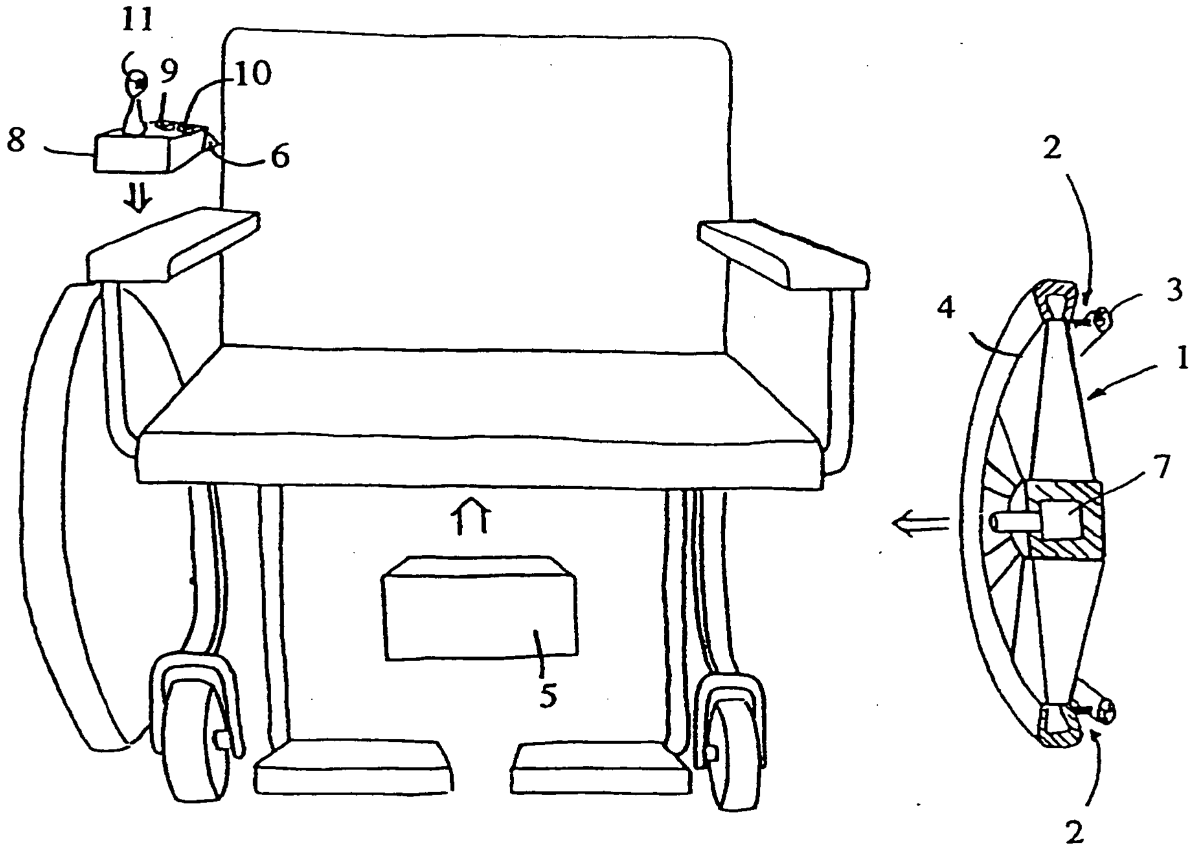


Fig. 1

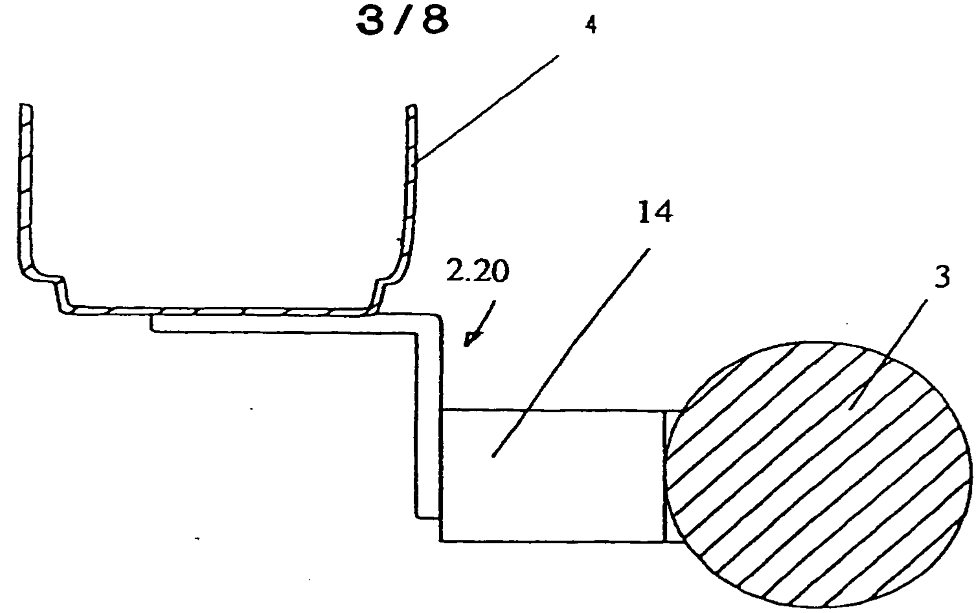


Fig. 3

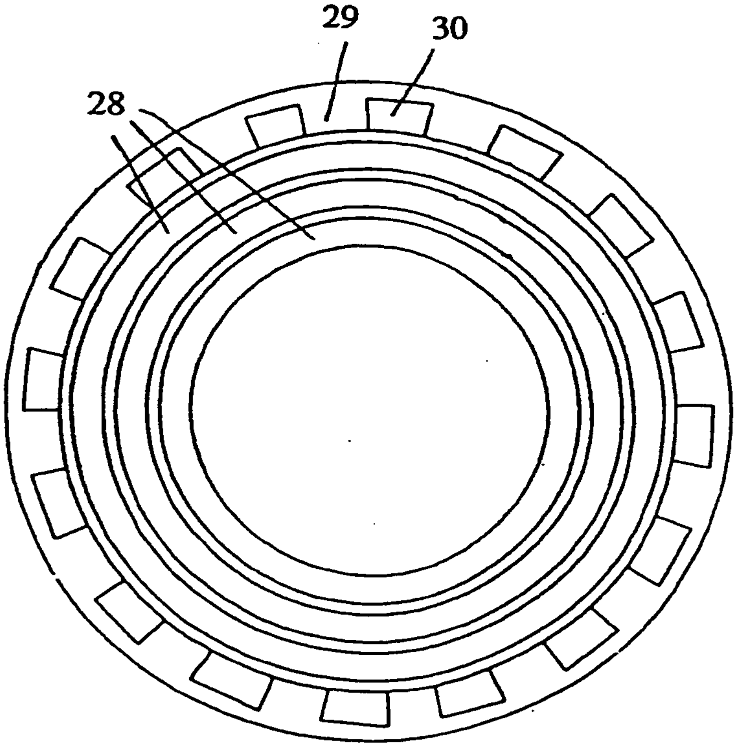


Fig. 2C

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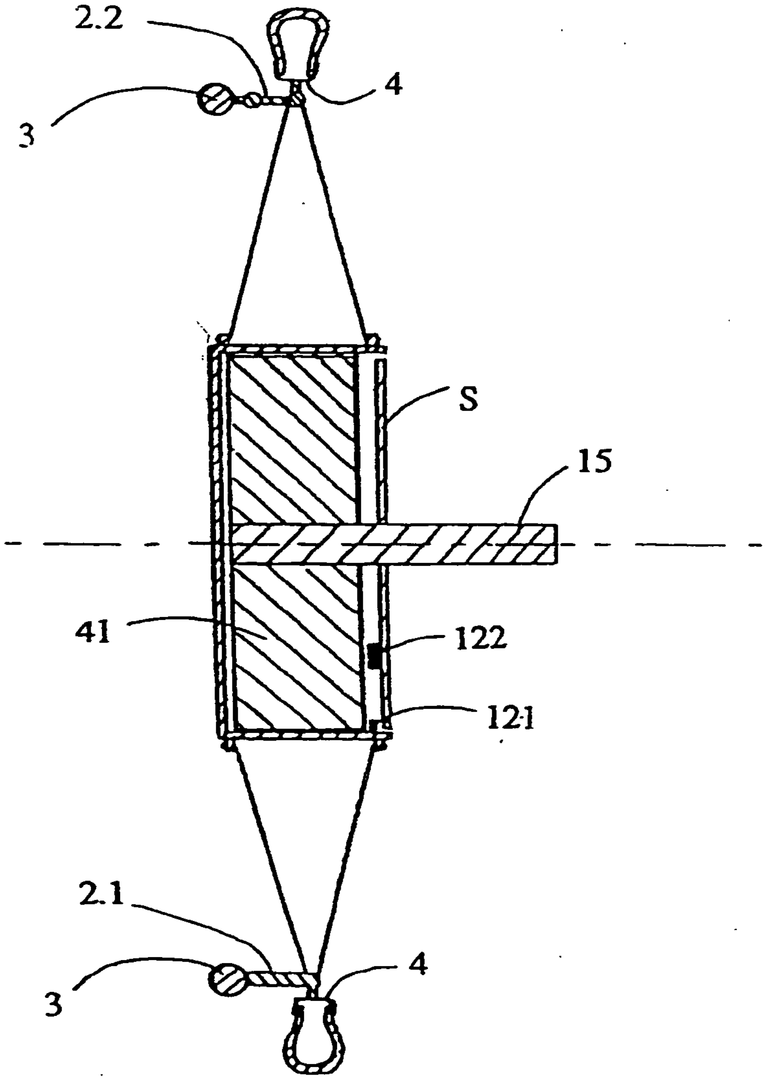
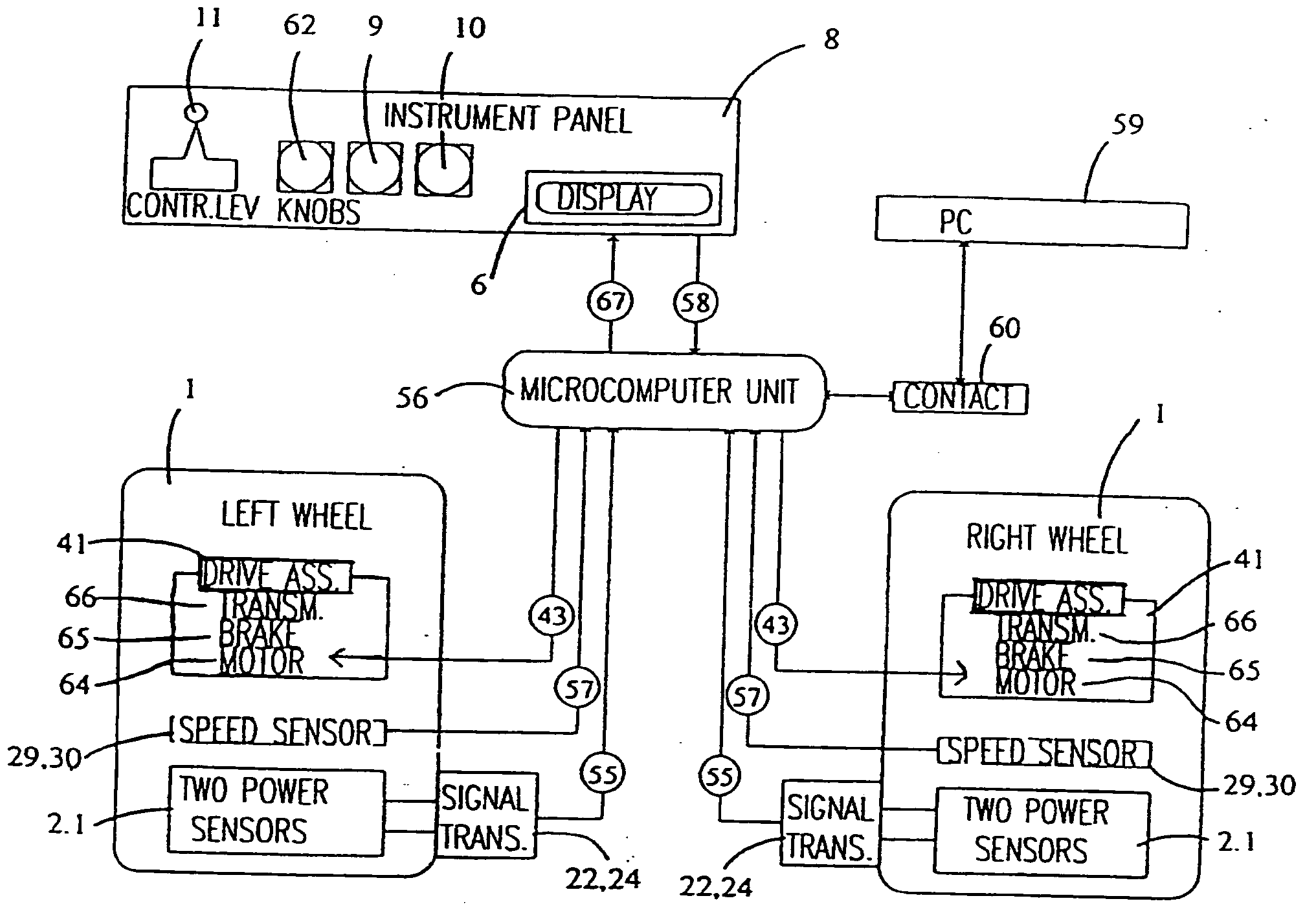


Fig. 5


11
62
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10
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KNOBS
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PC
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CONTACT
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LEFT WHEEL
41
DRIVE ASS.
66
TRANSM.
65
BRAKE
64
MOTOR
43
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29,30
SPEED SENSOR
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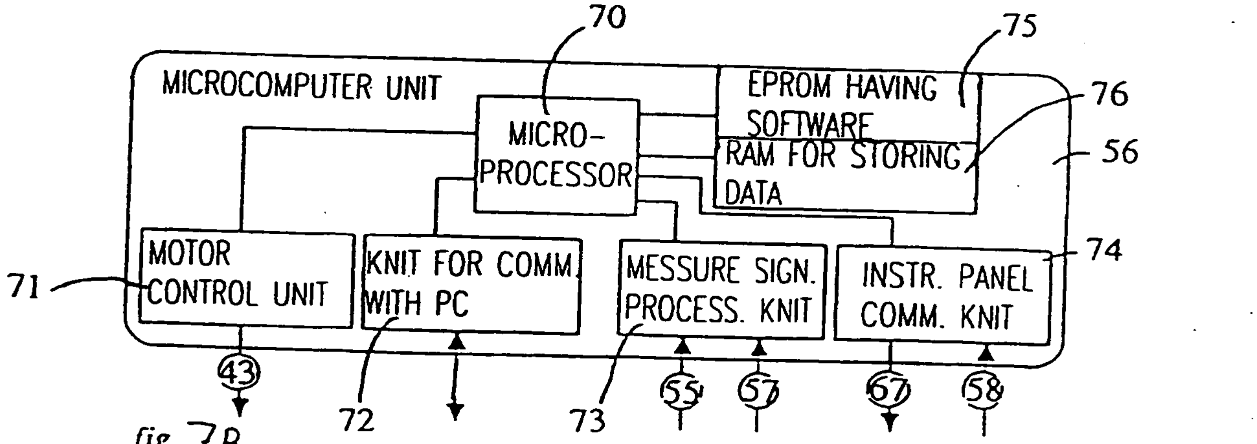
SIGNAL TRANS.
TWO POWER SENSORS
2.1
22,24

Fig. 7A


MICROCOMPUTER UNIT
MICRO-PROCESSOR
EPROM HAVING SOFTWARE
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KNIT FOR COMM WITH PC
MESSURE SIGN. PROCESS. KNIT
INSTR. PANEL COMM. KNIT

fig 7B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 94/00741

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: A61G 5/04
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: A61G, A61B, G01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 5234066 (AHSING ET AL), 10 August 1993 (10.08.93), column 4, line 54 - column 5, line 8	15,18,19
Y		16
A		1-14,17,20
	--	
Y	DE, A1, 4127257 (HAAS & ALBER HAUSTECHNIK UND APPARATEBAU GMBH), 18 February 1993 (18.02.93), abstract	16
	--	
X	US, A, 4050533 (SEAMONE), 27 Sept 1977 (27.09.77), column 2, line 20 - line 50, figures 2,3	15
A		1
	--	

☒ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

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Date of the actual completion of the international search 5 December 1994	Date of mailing of the international search report 08 -12- 1994
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Kenneth Gustafsson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

29/10/94

International application No.
PCT/SE 94/00741

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 5234066	10/08/93	NONE	
DE-A1- 4127257	18/02/93	AU-B- 654029	20/10/94
		AU-A- 2108992	18/02/93
		EP-A- 0528235	24/02/93
		JP-A- 5261132	12/10/93
		US-A- 5246082	21/09/93
US-A- 4050533	27/09/77	NONE	
US-A- 4125169	14/11/78	GB-A- 1587184	01/04/81
US-A- 4422515	27/12/83	NONE	

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